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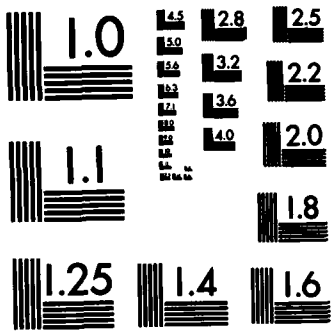

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A COMPARISON OF TWO METHODS FOR ESTIMATING THE ELECTRICAL SUPPLY CAPACITY OF NAVY PIERS

EG&G

A COMPARISON OF TWO METHODS FOR ESTIMATING THE ELECTRICAL SUPPLY CAPACITY OF NAVY PIERS

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Background.

Periodically, the fleet has reported difficulties with the electric power provided to its ships at various Navy piers. The Naval Facilities Engineering Command (NAVFAC) has initiated several projects to determine the nature of these difficulties. These projects address both the quantity and quality of electric power made available, the cable handling systems, and the design of distribution systems. NAVFAC's investigations have included the measurement of actual electrical usage - the two most comprehensive efforts being at Sewell's Point, Va. in December 1976 and January 1977, and the "Quick Look" project at U.S. Naval Station, San Diego, Ca. in March 1982. The results of the "Quick Look" study are reported in reference (a). Coincident with the latter, EG&G Washington Analytical Services Center, Inc. completed for NAVFAC the initial phase of development of the "Port Systems Requirements Prediction Methodology" (PSRPM), which uses the Sewell's Point data to predict electric power utilization. Reference (b) describes this methodology.

When designing a pier the Navy uses a technique, described in DM-25 reference (c), for sizing the electrical power distribution system. DM-25 is intended to satisfy long-term requirements. The procedure has been in existence for over 20 years as an accepted design practice. Some Navy officials question the design basis of this method for estimating capacity requirements for a specific population of ships at a pier.

The completion of the "Quick Look" project, the concurrent readiness of PSRPM, and the desire to assess the DM-25 method provided a propitious setting for comparing these methods of sizing electric power distribution systems. It was felt that this comparison would help solve the difficulties encountered by the fleet.

Objective.

The objective of this analysis is to compare two methods, DM-25 and PSRPM, for determining the electrical power required at Navy piers.

Scope.

The work reported herein includes the determination of a technique to compare the DM-25 process for sizing electrical systems at Navy piers with the predicted power utilization determined by using the PSRPM and the degree of confidence associated with that prediction. Once these actions have been completed it is possible to comment on the adequacy of the DM-25 process. It should be emphasized that the DM-25 is a capacity setting process while the PSRPM estimates the distribution of electrical power usage for any desired group of ships. A comparison of a capacity setting process with a utilization prediction procedure is dimensionally consistent, that is, both techniques are concerned with the amount of electric power. Essentially, this study displays two methods of deriving the electric power required at a specific pier. Additionally, since the results of this study are based on an actual measurement project, it is possible to reach some conclusions concerning measurement projects relative to their worth for design purposes.

This report is produced in summary form only. No attempt was made to document the means used to exercise the PSRPM. This will be done in detail in a follow on study scheduled for completion in May 1983.

Approach.

The approach taken in this study is to first establish two baseline pier and berthing scenarios by using actual conditions noted in the "Quick Look" study conducted at San Diego in early 1982. These will serve as the basis for both a power utilization prediction using the PSRPM and for a design capacity calculation in accordance with the design procedure of DM-25. At the same time the actual measurements recorded at San Diego are available to serve as an overall basis for comparison. This process is depicted in Figure 1.

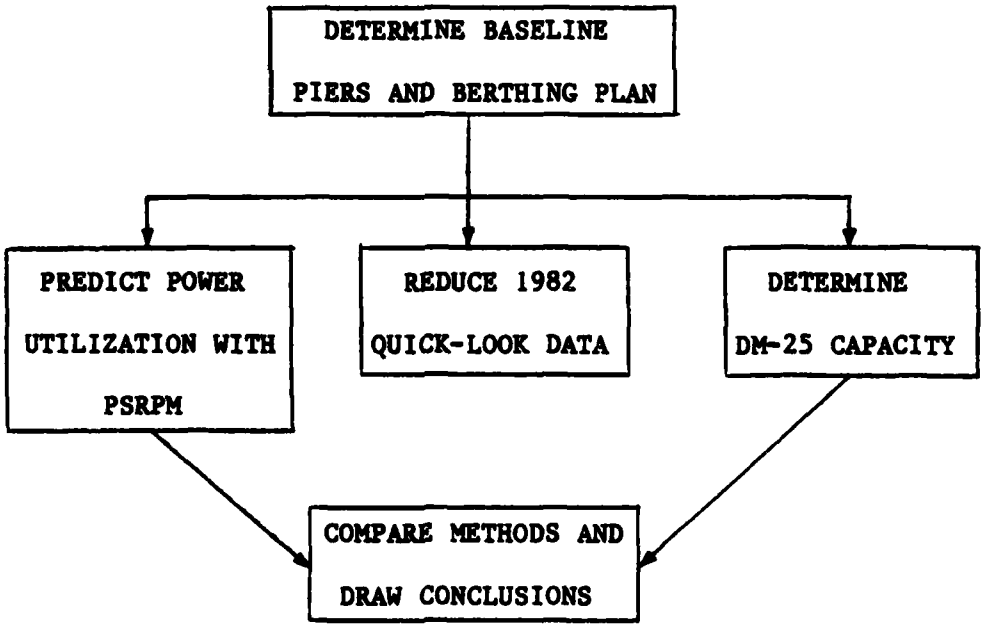

FIGURE 1. STUDY PLAN.

The resulting predictions, capacity determinations, and data reduction operations are then compared as a means of analyzing the various tools available for establishing the capacity of a port facility. This entire process, then, can be viewed as a basis for assessing the adequacy of the DM-25 design process as it relates to sizing power distribution systems.

Discussion.

It has been observed that the power utilization of a group of ships is less than the capacities of all the individual ships added together. This is attributed to both variation in an individual ship's demand and coincidental loading between ships, leading to a certain amount of diversity in the loading between two or more ships serviced from the same transformer. The DM-25 method accounts for this effect by taking the maximum designed electrical capacity of the various ships and reducing their sum by an amount dependent upon the number of ships serviced. However, the adequacy of the DM-25 design technique has never been formally validated. One output of the PSRPM is the mean and standard deviation of electrical power usage by ship class. This information is based on values recorded at Sewell's Point in 1976. It is these means and standard deviations which are used to predict the power used by the ships known to be in port at San Diego in 1982. Thus by using the same set of initial conditions the PSRPM can be used as a first level validation procedure for the DM-25 process. The availability of measurement data for this set of initial conditions then becomes a second level validation tool for the DM-25 process.

Baseline pier and berthing scenarios are based on actual conditions observed at Piers Two and Three at San Diego Naval Station, 32nd Street. The

electrical measurements span the period from 13 March through 25 March 1982. Tables 1 and 2 summarize the data for Piers Two and Three, respectively. These tables list the following information:

1. The ships in port each day
2. DM-25 electrical capacity for each ship class
3. PSRPM mean electric power utilization
4. "Quick Look" data converted from amps to kva
5. Pier electrical capacity using the DM-25 method
6. Pier electrical utilization using the PSRPM including:
   a. Mean, M
   b. Standard deviation, σ_{cov}
   c. Conservativeness factor, K. This is the number of standard deviations that the capacity derived by applying DM-25 is above the mean utilization predicted by PSRPM.

Figures 2 and 3 illustrate electric power (KVA) as a function of the day in port for Piers Two and Three, respectively. Each figure contains four plots.

1. A dotted line for the "Quick Look" electrical measurements
2. A solid line for the DM-25 capacity. The conservativeness factor, K, for each period of constant ship population is shown above this line.
3. A dashed line for the PSRPM predicted utilization
4. A short dashed line showing a conservativeness of ± 5. This implies that 99+% of electrical utilization is expected to lie within this band.

SHIP ELECTRIC POWER (KVA)			MARCH 1982												
CLASS	DM-25 CAPACITY	PSRPM MEAN UTILIZATION	13	14	15	16	17	18	19	20	21	22	23	24	25
AD-42	2493	781	X	X	X	X	X	X	X	X	X	X	X	X	X
DD-984	1090	324	X	X	X	X	X	X	X	X	X	X	X	X	X
DD-985	1090	324	X	X	X	X	X	X	X	X	X	16d			
DDG-7	1400	462	X	X	X	X	X	X	X	X	X	X	X	X	X
DDG-15	1400	462	X	X	X	X	X	X	X	X	X	X	X	X	X
DDG-31	1440	462	X	X	17d					8e	X	6d			
DDG-32	1440	462	X	X	X	X	X	X	X	X	X	X	X	8d	
FF-1051	685	111										14e	X	X	X
FFG-12	2180	1308	--	--	--	-8									
MEAN QUICK LOOK OBSERVATIONS KVA = (480/1000)AMPS	0100 TO 0800		2976	----	3438	2760	2850	----	----	2076	2850	2826	----	----	[illegible]
	0900 TO 1600		3204	----	3576	3186	3120	----	3000	2412	2382	----	2310	----	[illegible]
	1700 TO 2400		2844	----	2364	2976	----	----	2388	2520	2472	----	----	1512	----
DM-25 PIER CAPACITY (KVA)			6890 →		6190	→				6890 →		5980 →		5240	→
PSRPM PIER UTILIZATION (KVA) MEAN		M	3278 →		2816	→				3278 →		2603 →		2141	→
STANDARD DEVIATION		σ_{cov}	227 →		195	→				227 →		192 →		161	→
CONSERVATIVENESS FACTOR		K	15.9 →		17.3	→				15.9 →		17.6 →		19.2	→

LEGEND: X SHIP CONNECTED TO SHORE POWER.
- SHIP BERTHED AND CONNECTED TO OTHER UTILITIES, BUT NOT SHORE POWER.
c CONNECT TIME (e.g., 10c IS 1000 HOURS).
d DISCONNECT TIME (e.g., 7d IS 0700 HOURS).

TABLE 1. DATA SUMMARY. SAN DIEGO NAVAL STATION, PIER TWO, MARCH 1982.

SHIP ELECTRIC POWER (KVA)			MARCH 1982												
CLASS	DM-25 CAPACITY	PSRPM MEAN UTILIZATION	13	14	15	16	17	18	19	20	21	22	23	24	25
AR-6	1714	541	X	X	X	X	X	X	X	X	X	X	X	X	X
DD-845	1012	324							19e	X	X	X	X	X	X
DDG-13	1400	462	X	X	X	X	X	X	X	X	X	X	X	X	X
DDG-24	1400	462	X	X	X	X	X	14d	17e	X	X	X	24d		
DDG-33	1440	462	X	X	X	9d									
FF-1070	1355	429	X	X	X	X	X	X	X	X	X	9d		12e	X
FFG-2	1012	607							10e	X	X	X	X	X	X
LPH-11	3740	401	X	X	X	X	X	X	X	X	X	X	8d		19e
MEAN QUICK LOOK OBSERVATIONS KVA = (480/1000)AMPS	0100 TO 0800		2390	2229	2250	2239	1811	----	1546	2196	2115	2178	1931	1089	1618
	0900 TO 1600		2513	2338	2408	2048	1690	1741	1913	2347	2320	2212	1845	1694	1964
	1700 TO 2400		2398	2252	2184	1872	1561	1586	2302	2230	2076	2239	1582	1678	2002
DM-25 PIER CAPACITY (KVA)			8090 →			7320 →		6540	8400 →			7680	3750	4430	7660
PSRPM PIER UTILIZATION (KVA) MEAN		M	2759 →			2296 →		1834	3227 →			2798	1934	2363	2765
STANDARD DEVIATION		σ_{cov}	230 →			202 →		177	259 →			243	207	224	233
CONSERVATIVENESS FACTOR		K	23.2 →			24.9 →		26.6	20.0 →			20.1	8.8	9.2	21.0

TABLE 2. DATA SUMMARY. SAN DIEGO NAVAL STATION, PIER THREE, MARCH 1982.

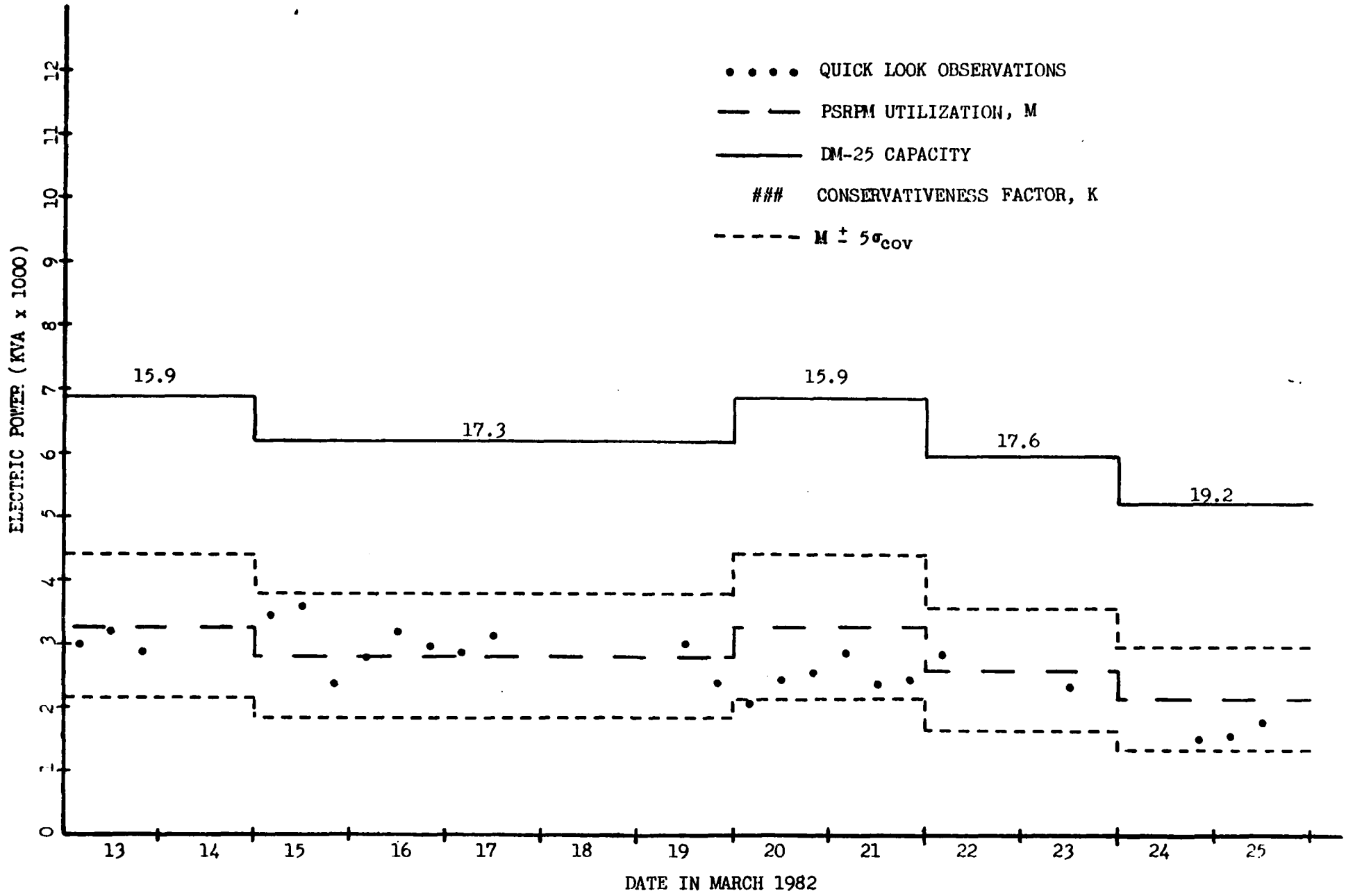

FIGURE 2. ELECTRIC POWER - SAN DIEGO NAVAL STATION, PIER TWO.

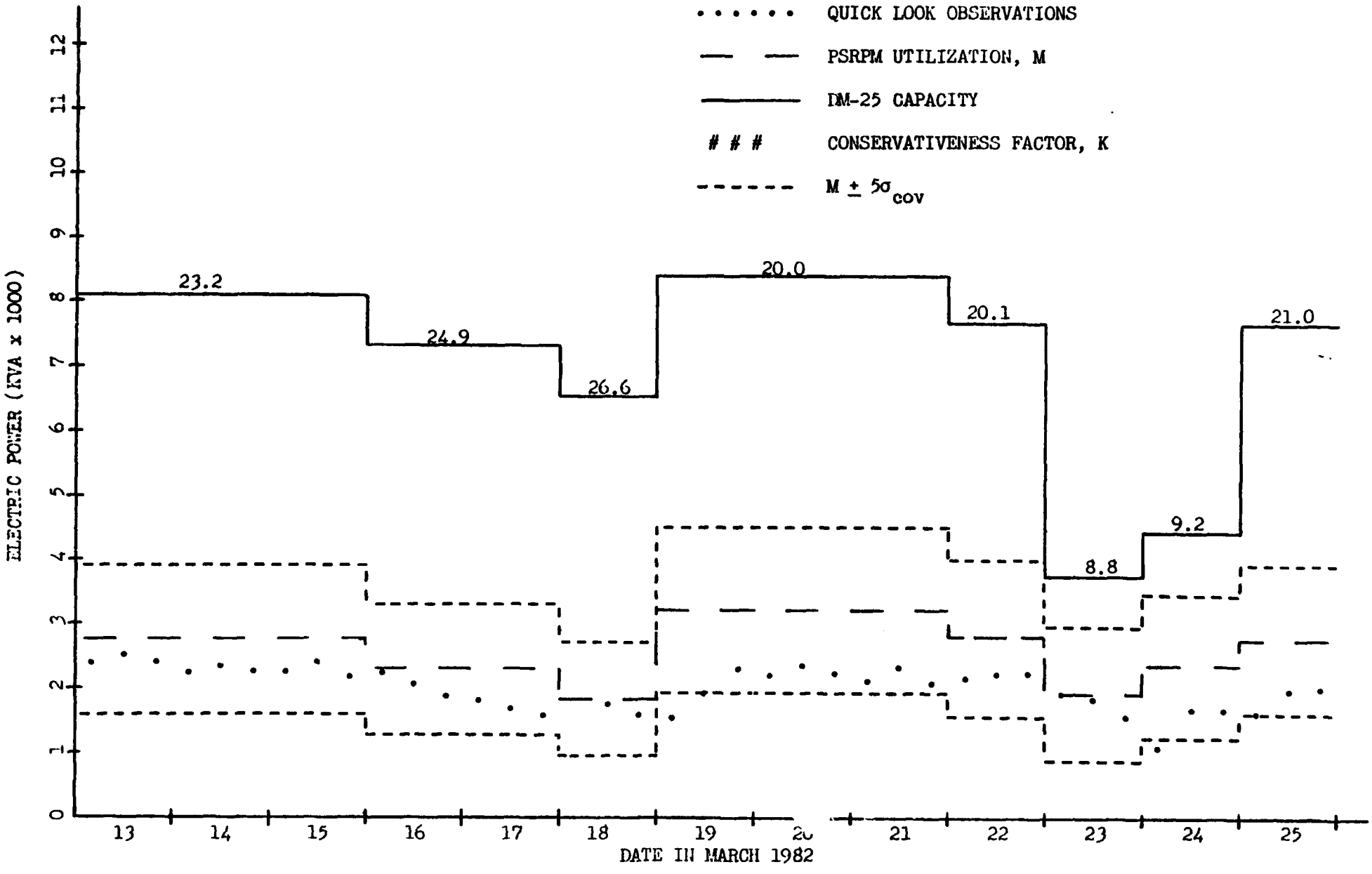

FIGURE 3. ELECTRIC POWER - SAN DIEGO NAVAL STATION, PIER THREE.

For both Piers Two and Three the DM-25 capacity was significantly higher than both the PSRPM predicted utilization and the measured electrical usage. This is not unexpected because the DM-25 procedure is intended to satisfy the power requirements at a pier for an extended period of time. By inspection of figures 2 and 3, the PSRPM prediction is in relatively close agreement with the actual "Quick Look" data, but it should be kept in mind that the statistical sample is small.

Conclusions.

The PSRPM provided an accurate estimate of the power used by the ships present at piers two and three, U.S. Naval Station, San Diego during the period of time in which the "Quick Look" measurements were made. Hence, the Port Systems Requirements Prediction Methodology has been validated to this extent. This is especially interesting in light of the fact that the data used for prediction was five years old and obtained at a different location. Furthermore, this study showed that the PSRPM can aggregate individual ship power usage data to predict usage by various combinations of ships and thereby is capable of predicting power use at the pier level. Finally, the DM-25 capacity setting process consistently provided a capacity that was noticeably higher than either the measured or predicted utilization. Thus, a design capacity derived from DM-25 will be conservative.

During this study, it was observed that the Sewell's Point data was incomplete in the sense that not all ship classses were accounted for. Some classes were not existing in 1976. Thus, some artificial data had to be constructed to accomodate the ships present in San Diego in 1982. This process

tended to cause small, but negligable, errors in the reported results. Additionally, different units of power were used in each data set. However, no significant variation is the results of this study are believed to have occurred as a result.

Recommendations

Even though the PSRPM process gives an accurate prediction, it is a complex procedure to use. Additionally, it makes no allowance for the increase in demand that occurs in the life span of a typical Navy ship. Hence it is recommended that the DM-25 process be continued as a direct, simple, and conservative process for designing the power capacity of permanent installations. PSRPM is useful and economical where where an estimate of actual utilization, rather than measured data, would meet the needs of the circumstances being investigated. However, the data base derived from the Sewell's Point data should be updated before additional applications of this nature are made. In fact the output of the current measurement program could probably be adapted to update the PSRPM data base. The PSRPM could then be used as an analysis tool for the current data acquisition project. Finally, it is recommended that in all measurement projects that the results be recorded in the same unit, preferably KVA, and that data be recorded at the ship level.

References

(a) Pierpoint, W.,and Edward Skillman. Quick-look Shore-to-Ship Electrical Measurements (Technical Memorandum #M-62-82-01). Naval Civil Engineering Laboratory, Port Hueneme, Ca. 93043 (April 1982).

(b) Summary Report: An Application of the Port Systems Requirements Prediction Methodology (PSRPM) Using Electrical Measurements Recorded at Sewell's Point (12-76 to 1-77). E G & G WASCI, Rockville, Md. 20850 (July 1982).

(c) Design Manual, Waterfront Operational Facilities, NAVFAC DM-25 (including changes 1 through 7). Dept. of the Navy, Naval Facilities Engineering Command, Alexandria, Va. 22332 (October 1971), pp. 25-3-12 to 25-3-20.